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Geotechnical Characterization of Alluvial Soil in Çiğli - Balatçık Region

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ABSTRACT

The alluvial deposits have high vertical deformation, low bearing capacity and shear strength because of their organic matter content and high void ratio. Therefore, for the project designed on the alluvial deposit, it is necessary to determine the geotechnical engineering properties in detail. In this study, physicochemical engineering properties and compressibility behavior of the alluvial soil taken from Çiğli - Balatçık in İzmir were examined. Alluvial soil samples were taken from each 1.5 m depth for 30 m. Wet sieve analysis, fall cone penetration, plastic limit, pH, specific gravity, organic matter content and one-dimensional consolidation tests were conducted to determine geotechnical index properties and compressibility parameters of alluvial samples. The specific gravities varied between 2.62 and 2.83 and the liquid limit values were ranged between 21.8 – 66.5%. The sieve analysis and consistency limits tests results were evaluated according to USCS, it was determined that the soil contains large amounts of low plasticity silt and low plasticity clay (ML and CL). The pH value ranged between 7.65 and 8.76. The results of one dimensional consolidation tests showed that, compressibility indices and swelling indices were range between 0.268 – 0.490 and 0.058 – 0.158, respectively.

Keywords: Alluvial soil, compressibility, consolidation, geotechnical index properties.

INTRODUCTION

It is very important to examine and evaluate the geotechnical properties of the alluvial soil comprehensively for geotechnical design projects. Alluvial deposits have not fully completed geological formation which causes them to have a high void ratio. Alluvial soils have high vertical deformation and low bearing capacity and if required precautions are not taken, these adverse properties of alluvial deposits can negatively affect the design process. There are many studies that conducted about alluvial deposits in the literature.

Yilmaz and Karacan (1997) determined the geotechnical properties of alluvial soil for south of Sivas. In order to detect shear strength and consolidation behavior, six undisturbed and twenty-one disturbed soil samples were taken from different locations and laboratory tests were conducted. The test results showed that liquid and plastic limits were range between 51 and 67%, 20 and 31%, respectively. Specific gravities were ranged between 2.27 and 2.66. The alluvial soil was commonly classified as high plasticity clay (CH). In the light of these results, foundation problems were evaluated.

Cobanoglu and Bozdag (2007) examined the index and consolidation parameters of the alluvial soil of Adana in Turkey. Test results have shown that liquid and plastic limits were ranged between 37.7 and 68.1%, 14.7 and 32.6%. The natural unit weight was found between 16.2 and

21.4 kN/m^3. Consolidation test results presented that swelling index (C_s) and compression index (C_c) changed between 0.0025 – 0.0083 and 0.048 - 0.085. Also, a data bank was formed that includes geotechnical parameters obtained from test results by using Arcview, Geographic Information System program. SPT-N, resistivity, soil amplification, shear rate, bearing capacity maps were created for study area.

Yilmaz and Karacan (2002) detected the index properties, consolidation, and swelling characteristics of soil samples collected from Erbaa Basin, Turkey. The test results showed that liquid and plastic limits get values 26 – 57% and 12 – 28%, respectively. The pH and OMC values were ranged between 7.2 – 7.5 and 0.7 – 1.4%. Natural unit weight and specific gravity were between 16.7 – 19.7 kN/m^3 and 2.64 – 2.78. Compression and swelling indices got values between 0.15 – 0.49 and 0.03 – 0.09. The swelling potential was specified as medium to high. Because of their high consolidation level, the soils had high bearing strength. Therefore, instability problems of foundation were not expected.

Bolat et al. (2005) analyzed the physicochemical properties of alluvial soils in Ömerli, Istanbul. For this purpose, the physico – mechanical properties were designated with laboratory and in-situ tests. Natural water content and natural unit weight were found from 0 to 45% and from 1.7 to 2.7 t/m^3. Plastic and liquid limits were ranged between 10 – 30% and 20 – 70%. SPT – N values were between 0 and 40. Specific gravity values varied between 2.5 and 2.8. As results of sieve analysis, it was seen that the alluvial soil had rich in clay and silt. According to USCS, the dominant soil was classified as low plastic clay (CL). Because of the low bearing capacity of alluvial soil, the authors emphasized that concerned area was not suitable as a construction site.

Tan et al. (2004) made a series of subsurface investigation including in-situ and laboratory tests has been carefully planned and carried out for the residential and commercial development over soft marine clay at Bukit Tinggi, Klang, Malaysia. Test results have shown that the unit weights were ranged between 12 and 19 kN/m^3. Plasticity and liquidity indicis ranged between 20 – 90 , 0.2 – 1.2, respectively.

In this study, geotechnical index properties and compressibility behavior of alluvial soil taken from İzmir Katip Çelebi University in Çiğli-Balatçık were investigated. Alluvial soil was classified with wet sieve analysis, falling cone penetration, plastic limit tests according to USCS. Specific gravity, organic matter content and pH tests were conducted to define basic engineering properties of alluvial soil. Compressibility behavior of alluvial soil was defined with one dimensional consolidation test.

MATERIALS AND METHODS

The alluvial soil samples were taken from the Çiğli – Balatçık region (İzmir, Turkey). General view of Balatçık region has shown in Figure 1.

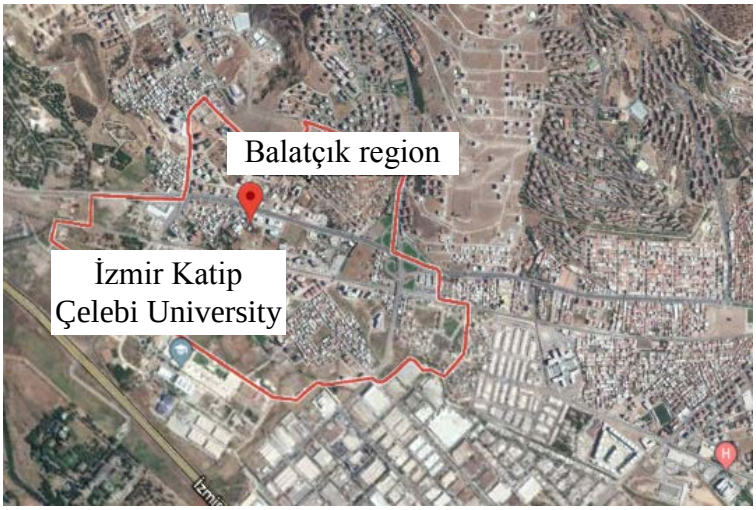

Figure 1. General view of Çiğli – Balatçık.

The alluvial deposit samples were collected from the construction site placed at İzmir Katip Celebi University. The alluvial soil samples were taken for each 1.50 m from 30 m borehole. The samples were immediately covered with nylon to preserve the natural properties and packed tightly to avoid evaporation. Then, the soil samples were transferred to the soil mechanics laboratory.

All experiments were conducted according to ASTM (American Society for Testing and Materials) and BS (British Standards) procedures.

The specific gravities of alluvial soil samples were determined according to procedure given in ASTM D854-14. In this test, vacuum pump, pycnometer, 25 g sample and distilled water were used.

The digital pH meter were used to define the pH values of alluvial soil samples. The suspension was prepared by mixing 125 ml air-free distilled water and 50 g sample and to stand for 24 hours (Figure 2). Each measurement was performed twice to check repeatability (Kocasoy, 1996).

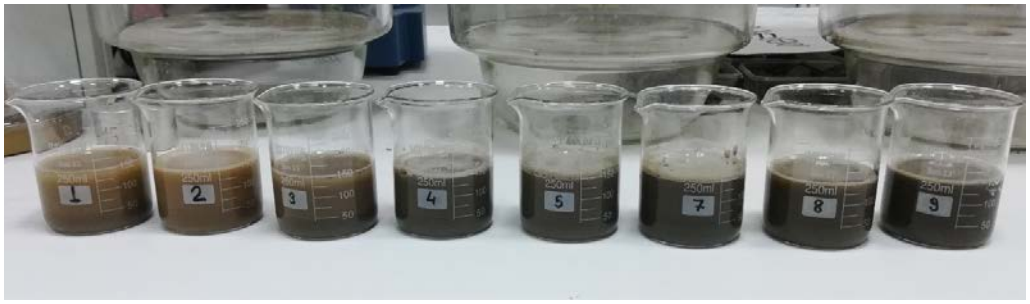

Figure 2. Alluvial samples for pH tests.

To define the organic matter content (OMC), the alluvial soil was ignited in the furnace for 24 hours at 440 °C, according to ASTM D2974 – 14.

The particle size distributions were specified with wet and dry sieve analysis for all samples. After the wet sieve analysis were completed, dry sieve analysis was organized (ASTM D422-07 and ASTM D6913-04).

Plastic limits were defined in accordance with ASTM D4318-10. Liquid limits were determined with fall cone test method according to BS1377-1:2016. The alluvial soil specimens were classified using grain size distribution and Atterberg's limit results according to Unified Soil Classification System (USCS) (ASTM D2487-11). The fine grained clay (C) and silt (M) soils were classified using liquid and plastic limits according to plasticity chart proposed by Casagrande.

In order to determine the compressibility behavior of alluvial soil samples, the one dimensional consolidation tests were performed for undisturbed clay (27.0 – 28.5 m) and silt (18.0 – 27.0 m) samples in accordance with ASTM D2435/D2435 – 11. The seating pressure of 5 kPa was applied for each soil sample before the loading period was started. The samples were loaded with 24.5 kPa, 49 kPa, 98 kPa, 196 kPa, 392 kPa and 784 kPa of normal stresses, respectively. Then same samples were unloaded with 196 kPa and 49 kPa normal stresses to investigate swelling characteristics. The consolidation tests were repeated two times for each sample to check the repeatability. Casagrande method (t_{50}) was used to determine coefficient of consolidation (c_v).

RESULTS AND DISCUSSION

Idealized soil profile of the alluvial deposit was generated with sieve analysis and Atterberg's limit results (Figure 3).

BH	G (%)	S (%)	M+C(%)	
				0.0 m
SM	1	61	38	1.5 m
CL	2	31	70	3.0 m
SC	0	93	6	7.5 m
SM	5	72	28	9.0 m
CL	1	33	66	10.5 m
SC	0	60	40	12.0 m
SM	0	85	14	18.0 m
CL	0	6	94	21.0 m
ML	0	33	67	27.0 m
CL	8	27	65	28.5 m
GM	47	22	31	30.0 m

Figure 3. Idealized soil profile.

The consistency limits, specific gravity (G_s), pH and soil class of alluvial samples have been listed in Table 1.

Table 1. The physicochemical parameters of alluvial soil.

Depth (m)	LL (%)	PL (%)	Gs	pH	USCS
0.0 – 1.5	30	NP	2.62	8.41	SM
1.5 – 3.0	25	22	2.75	8.76	CL
3.0 – 9.0	25	NP	2.83	8.15	SC
9.0 – 10.5	24	23	2.81	7.65	SM
10.5 – 13.0	22	NP	2.68	8.01	CL
13.0 – 16.5	27	NP	2.8	7.82	SC
16.5 – 18.0	30	NP	2.64	8.45	SM
18.0 – 21.0	35	25	2.73	8.44	CL
21.0 – 27.0	30	30	2.67	8.41	ML
27.0 – 28.5	36	27	2.68	8.29	CL
28.5 – 30.0	40	24	2.70	8.3	GM

The physicochemical parameters of alluvial soils used in the present study are closely related to literature studies (Masaud, 2015).

The void ratio (e) and effective vertical stress (σ') relations of fine grained samples have shown in Figure 4.

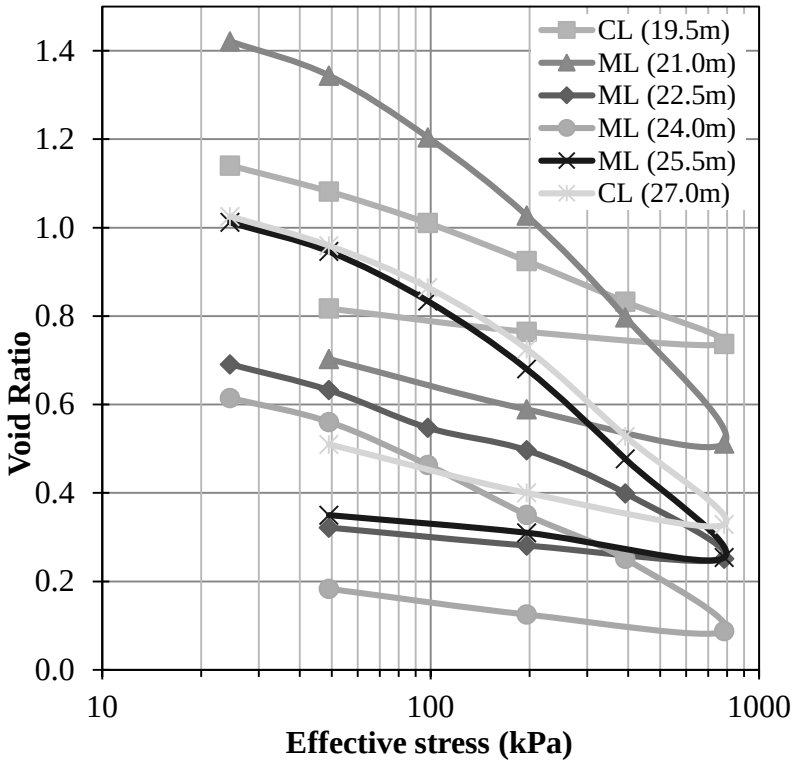

Figure 5. The relation of void ratio (e) - effective vertical stress (σ'_v).

As a results of one-dimensional consolidation test, the compression index (C_c), swelling index (C_s) values of samples were obtained (Table 2).

Table 2. One-dimensional consolidation test parameters.

Depth (m)	Sample	Consolidation test		Terzaghi and Peck
		C_s	C_c	C_s = 0,009.(LL-10)
19.5	CL	0.087	0.265	0.162
21.0	ML	0.158	0.422	0.180
22.5	ML	0.058	0.285	0.126
24.0	ML	0.080	0.366	0.135
25.5	ML	0.093	0.490	0.108
27.0	CL	0.151	0.449	0.225

Terzaghi and Peck (1967) proposed an equation to determine compression index of normally consolidated fine grained soils. When the compression indices obtained from consolidation tests were compared to equation results, it was seen that the values derived from equation were lower then test results. This is due to the fact that the alluvial soils have not completed the geological formation and that large vertical deformations were observed.

Consolidation test results are in a good agreement with literature studies. Yılmaz and Karacan (2002) examined the geotechnical properties of clayey alluvial soils in the Erbaa Basin, Turkey. Researchers reported the minimum and maximum compression indexes as 0.15 and 0.49, respectively. Zarif (1995) examined the consolidation behavior of alluvial soft soils on Anatolian motorway between Kazancı-Gümüşova. The author determined the maximum and minimum compression indices as 0.18 and 0.37.

CONCLUSIONS

Alluvial deposits contain materials with different engineering properties from colloid to boulder. This complex structure brings with some uncertainties which must be examined comprehensively. In this study, the alluvial soil samples taken from Çiğli-Balatçık region were analyzed. Idealized soil profile derived from laboratory tests, proved that the characteristics of soil layer changed in a narrow spacing. Generally sand layer with fine grained particles is defined to a depth of 18 m from the ground surface. The low plasticity silt (ML) and the low plasticity clay (CL) layers at 18-28 m depth are followed the sand layer. In the end silty gravel (GM) layer is located. Test results were shown that all alluvial soil samples with pH values greater than 7 were basic. Compression indexes of low plasticity silt and high plasticity clay samples comparatively much higher than compression indices obtained from the correlation equation proposed by Terzaghi and Peck (1967). Consolidation test results have proven that alluvial deposits have high void ratio and high axial deformations.

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